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Preface

The distributed model intercomparison project (DMIP)

Considerable effort in the last 30 years has been directed into the research and development of distributed hydrologic models. Early work with such models was often hampered by excessive data requirements and computer processing and storage capabilities that were inadequate to solve the numerous and complex physics-based equations.

To a large extent, ongoing technological advances have alleviated some of the data restrictions and most of the computational barriers to distributed modeling. Recent data collection advances, most notably the use of weather radar platforms to gather high resolution precipitation estimates, have instilled new enthusiasm into distributed modeling. Similarly, airborne and satellite-based sensors are providing data ranging from detailed measurements of the terrain to surface soil moisture measurements and estimates of vegetation extent and activity. More and more, data sets that originally existed in paper-map form are being converted to electronic format and made readily available. Complementing these advances, seemingly exponential increases in computer data storage and processing speeds have allowed scientists to examine watershed behavior at unprecedented scales and with complex equations. As a result, it is not uncommon to have distributed models with hundreds or thousands of computational elements running at time steps of an hour or less. GIS capabilities allow modelers to manipulate monstrous volumes of spatial data. Furthermore, tools to support distributed modeling are now standard features in several commercial GIS packages. While the initial cost of gathering data for hydrologic modeling is still present, once the data is collected, it can usually be easily transformed into useable forms for modeling studies. Web-based servers and data repositories are rapidly evolving so that modelers can quite easily share basic data and derivatives. Thus, the so-called institutional problem of one group, agency, or institution not being able to manage and/or disseminate all the data needed for distributed modeling is also being addressed.

Along the way, distributed models have been developed to address a wide variety of issues, some research-oriented and others more practical in nature. Such models have been developed to simulate the movement of pollutants and to predict the effects of land use changes. Others are used as a means to explore our knowledge of the physics of water movement in a catchment, and to form a computational test bed for improved algorithms. On a practical level, some distributed models have migrated into the civil engineering arena for use in design and planning studies. In addition, distributed models are beginning to make inroads into the operational river forecasting environment. More recently, distributed models are being viewed as candidates for the land-surface component of numerical weather and climate prediction models.

Such advances have paved the way for hydrologists to examine fundamental questions related to the science of distributed modeling with renewed vigor, so as to move closer to the awaiting practical problems. The papers in this volume make clear that there is much room for continued research on significant science issues. For instance, what is the nature and impact of spatial variability of basin physical characteristics and forcings? What role does parametric and data uncertainty play in the realization of benefits from distributed models? Are there dominant, effective, or representative scales in hydrology? What is the nature of variability at the sub-computational element (e.g. grid) scale? What calibration strategies are needed? What level of model complexity is needed to achieve a desired result? There seems to be two parts to this last

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question: what is the optimal level of basin disaggregation to capture essential spatial variability, and what level of scientific complexity is required in the algorithms that describe the movement of water? What is the nature of error propagation through distributed models? What assimilation techniques are needed? There is even debate as to whether so-called physically based distributed models are in reality lumped conceptual models operating at the grid scale. While much has been learned, few would argue that these and other questions are far from being sufficiently answered.

Here, we submit the results of DMIP to the body of literature as a contribution to both the scientific and practical engineering questions regarding distributed modeling. This issue forms the culmination of what we hope is only the first of several DMIP efforts. While this initial DMIP project concentrated on simulation intercomparisons, future DMIP phases may contain a test of distributed models in a pseudo-forecast environment. The unifying thread running through this and future DMIP efforts is the eventual implementation of a distributed model for real-time hydrologic forecasting.

We are encouraged that already there is interest in additional phases that address distributed modeling in other geographic regions and with other data for model validation. Moreover, we hope that DMIP will encourage others to organize similar efforts. Future DMIP projects could also serve as useful links to other important initiatives such as the Prediction in Ungaged Basins (PUB) effort. For example, improved predictions with reduced uncertainties for interior locations of a watershed through DMIP may shed some light on relevant PUB questions.

This issue presents work performed in the initial and follow-on phases of DMIP. The initial phase focused on the generation and analysis of participants' simulations. In August 2002, the NWS convened a workshop of DMIP participants to present the results and analyses. At this workshop, the participants enthusiastically decided to conduct follow-on research to refine their models and simulations and to investigate issues relevant to the DMIP basins.

The papers in this issue are organized into four sections: (1) overview of the distributed model intercomparison project, (2) specific models and issues, (3) distributed modeling and uncertainty, and (4) other DMIP science questions. Two papers comprise the first section: one outlines the motivation and experiment design of DMIP, while a companion paper presents the analyses of the formal simulations submitted to HL and analyzed for the August, 2002 workshop. Subsequent sections of this issue present the details of some participating DMIP models and also cover follow-on research conducted after the August, 2002 workshop. In section two, six papers present specific modeling approaches and discuss improved simulations developed after the August 2002 workshop. In the third section, we present three papers dealing with distributed modeling and uncertainty. Here, one paper deals with the effects of uncertainty in model parameters and precipitation estimates. Another paper in this section seeks to address uncertainty through multi-model ensemble analysis, while the final paper in this section looks at uncertainty resulting from different model structures. In the last section, three papers address other DMIP science questions. First, the spatial variability of precipitation is examined versus gains from distributed versus lumped modeling approaches. Next in this section is a paper on the optimal size of computational elements for a basin. Completing this section is a paper examining the hydrologic effects of using two precipitation sources provided in DMIP.

The Guest Editors wish to recognize the many reviewers who through their efforts contributed to a scientifically sound special issue. We gratefully acknowledge support from all the participants' respective institutions for providing the resources to participate in DMIP. We thank Chief Editor Dr Roman Krzysztofowicz for initiating this special issue and inviting us to be guest editors. It has been a privilege for us to shepherd the papers through the review process. We also thank the staff at Elsevier Publishers for their guidance and patience as this issue was prepared.

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